SAFETY ASSESSMENT WALK-THROUGH
FOR
WBS 1.1.5: NEUTRINO BEAM MONITORS

I. Introduction

The neutrino beam monitoring system is comprised of four arrays of gas-filled ionization chambers. The first array is contained in a single vessel 30” by 30” located in a cavity in the hadron absorber and is referred to as the “hadron monitor.” The subsequent three arrays are contained in sets of 9 detector ‘tubes’. Each set of 9 tubes are mounted on support stands in the three muon alcoves. The locations of the monitors are noted in Figure 1.

The monitoring system has several subsystems which require proper safety precautions. The purpose of this memo is to enumerate those potential safety hazards and the precautions or mitigative steps taken. In brief, the subsystems and potential hazards therein are:

1. Gas System: this system delivers gas to the detectors. The potential hazards are exposure to high pressure lines, oxygen deficiency hazards (ODH), electrical shock from the wiring for the instrumentation used to monitor system flows, and flammability of cables.
2. High voltage system: the detectors require bias voltages 100-500 V, which poses potential electrical shock, and flammability of cables.
3. Electronics readout: issues are mainly flammability of cables.
4. The detector vessels: the muon tubes have internal radioactive sources.

For each of these *potential* hazards we review in brief the mitigative steps taken to reduce risk and the required procedures for safe handling (in the case of the radioactive sources).

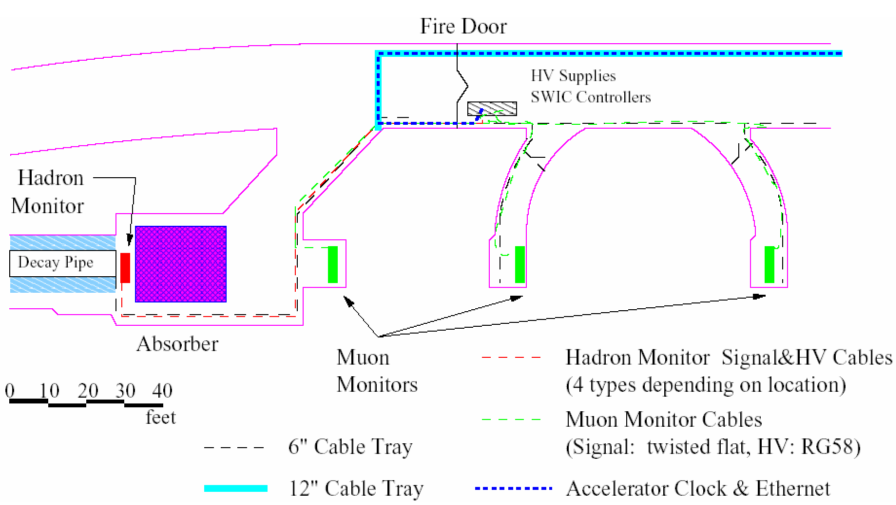

Figure 1: Geographic layout of the WBS 1.1.5 neutrino beam monitoring system.

Figure 2: (left) 8-cylinder manifold of He gas which supplies the system. (right) Gas system distribution rack AAT101 located in the absorber access tunnel near Alcove 2.

II. Gas Delivery System

The beam monitor chambers require pure Helium gas flow. The He comes from an 8-cylinder manifold located at the north side of the bottom of the MINOS shaft. The cylinders are 216 cf, 2400 p.s.i and are standard stock from the Fermilab stock room. A stainless manifold with high-pressure one-way valves safely permits removal of one cylinder while 7 full cylinders are still in place, even if the operator neglects to close the valve. A dual-stage stainless regulator steps the pressure down to 65 p.s.i for the long ¼" OD line which supplies the gas to the distribution rack located in the absorber access tunnel at AAT101, approximately 600' away. No cables span this 600' distance, only ¼" stainless tubing. The tubing is secured to unistrut supports using conduit clamps with 2" segments of (possibly flammable) air hose used to fill the space in the conduit clamp. These conduit clamps are located at approximately 10' intervals [i].

The gas distribution rack fans the 65 p.s.i supply to four independent output circuits, each at approximately 0.5 p.s.i gauge pressure. The gas distribution rack has several electrical instruments to measure gas flow, pressure, and temperature. These are powered from inside the rack, and include:

1. Sierra 820 mass flow meter. Powered by a 24VDC supply, 100 mA max current draw. The flow meter outputs a 0-5 VDC signal.
2. MKS Baratron 870B pressure transducer. Powered by 24 VDC, 10 mA max. Output signal is a 0-5 VDC signal.
3. Omega Engineering PX300 pressure transducer. Powered by 24VDC, 10mA max. Output signal is 0-5VDC.

The output analog voltages from these transducers are read using standard Accelerator Division MADC units, and are displayed on LCD panel meters (Omega Engineering Model DP24-E). The panel meters are powered by 120VAC, 30 mA max. All wiring was performed with appropriate gauge wiring. Following guidance from Bob Ducar, no checks were performed on the flammability of cables within the racks.

Four MKS pressure transducers are also located near the detectors and are both powered from and read out at the gas distribution rack AAT101. The power and read back signal are both conducted in Belden 8762 4-conductor shielded cable layed in the cable trays. This cable has been tested to be flame retardant.

Relief valves of 3 p.s.i at the rack and of 0.5 p.s.i at the detectors prevent over-pressure of any part of the system. The muon monitors have been tested to 4 p.s.i and the Hadron Monitor to 0.25 p.s.i. The rack instrumentation can tolerate 100 p.s.i.

ODH calculations have been performed by Dave Pushka using the following inputs: Each muon tube (27 in total) is 17 liters in volume, and the Hadron Monitor is ~40 liters, totaling 550 liters of detectors. The 1300' of ¼" OD tubing add an additional 2 liters of gas volume. A flow rate of 2-4 volume exchanges per day is envisioned. The ODH calculation was performed assuming that all gas would be exhausted in the alcoves or in the absorber hall, which is in fact where the exhaust lines are located.

III. High Voltage System

Bias voltages are delivered to the detectors from Fermilab Droege current-limiting power supplies obtained from PREP. The power supplies are modified to restrict the output voltage from 0-1000 VDC, not the usual 3 kV or 5 kV. The Droege's number 20 in total and are located in NIM crates in rack AAT102. The Droege's are remote-controllable in ACNET via analog voltage inputs at their rear. The 0-2 VDC analog voltage inputs are supplied by Accelerator Division CAMAC052 DAC cards and cables made under guidance from Bob Ducar and Mike Kuplic from AD.

Bias voltages are delivered from the AAT102 rack to the detectors via RG58/U cables terminated with SHV plugs by the Accelerator Division Instrumentation Department. All voltages are 200-300 VDC and will be current-limited to 100 micro-Amperes.

At the muon detectors, the high voltage cables are hard-soldered to printed circuit boards on the detectors. The printed circuit boards have exposed high voltage (up to 500V). In order to protect personnel from this voltage hazard, grounded aluminum box covers are mounted over every muon tube to prevent direct contact. On the hadron monitor, aluminum transition boxes from RG58/U cable to kapton coax cable protect personnel.

Figure 3: (left) View of the lower end-plates of the muon tubes showing high voltage feedthroughs. (right) view of muon tubes without and with an aluminum HV shield.

IV. Electronics System

The readout electronics consist of all standard Fermilab components: the electronics are SWIC scanners located in AAT102. The cables from the detectors to the scanners are the same 50-conductor shielded twist-n-flat used elsewhere in the lab, as for example with multiwires in the primary beam line. These cables have been shown to be flame-retardent.

V. Radiation Safety

The muon tube detectors each contain nine 1 μCi alpha sources (Americium-241). These sources are used during beam operations to verify the detectors are functional. The hadron monitor contains no radioactive sources.

The sources were measured by ES&H staff at the University of Texas at Austin and received into the inventory here at Fermilab by the ES&H Department here (Kathy Graden) and the NuMI RSO, Mike Gerardi. Surveys of the sealed muon tube detectors by UT ES&H indicate <1 mR/hr on contact from the internal sources. Our agreement with Fermilab ES&H is that no special precautions are required for handling of the muon tubes, with two exceptions:

(1) moving the tubes to another location on site at FNAL will require an RSO to move them, and

(2) opening the detectors for repairs will require us to contact the RSO for implementation of proper handling procedures.

Neither of these steps should ever be required if the detectors function properly. Furthermore, 3 'hot spare' detectors are located in Muon Alcove 4 should any problems with the installed detectors arise.

It should be pointed out that the hadron monitor will not be easily removed once beam has run. After 1 year running and 1 week cool-down period, it is estimated that the hadron monitor will be activated to 58 R/hr.

Notes

[i] At some locations the ¼" stainless tubing is affixed under the cable trays using cable ties. In these regions no unistrut was easily found to which the tubing could be mounted, and we noted that many other cable ties had been used in these areas for other lines.